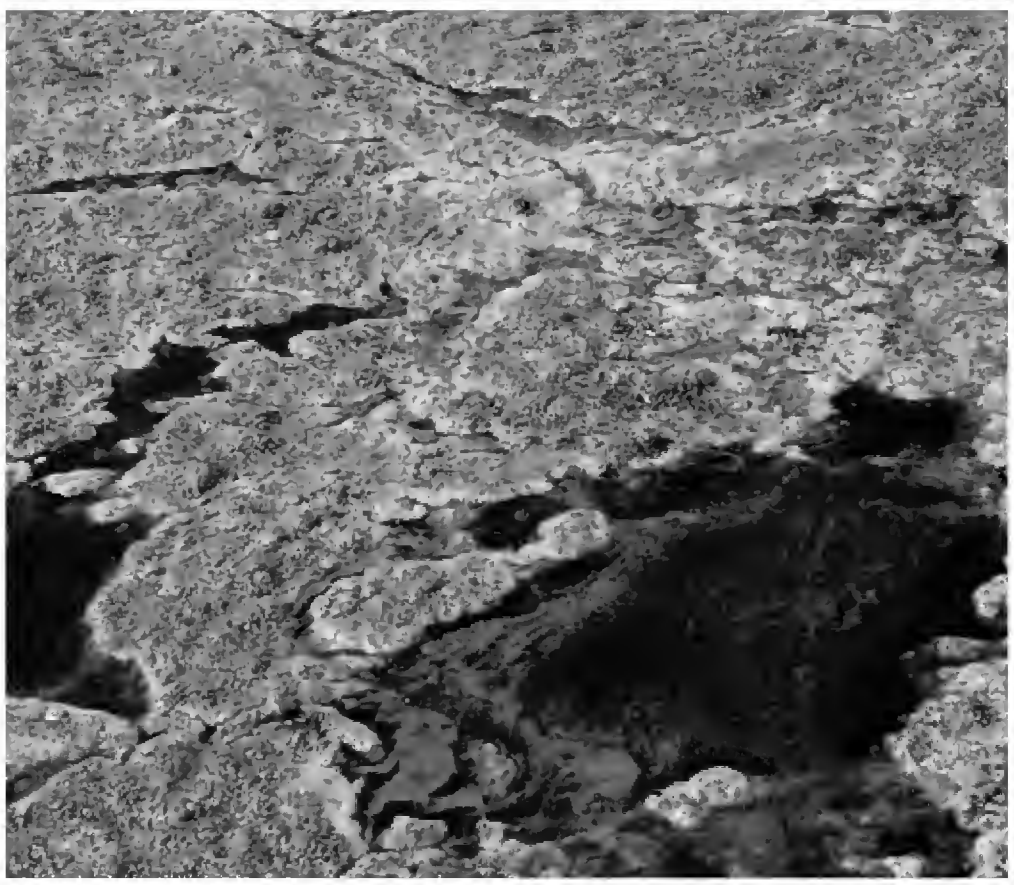
CHESAPEAKE BAY FOUNDATION

Saving a National Treasure

REPORTS



Bad Water and the Decline of Blue Crabs in the Chesapeake Bay

Overfishing
Overfishing is used here not to mean the illegal catching of crabs, but as a technical term that describes when the rate of crab harvest exceeds the accepted science-based limit (46 percent of total crab population annually). Harvesting above this sustainable threshold removes crabs faster than reproduction and growth can replace them, causing the population to decline.

ABOUT THE COVER:

Upper Left: Pushed to shore by a dead zone, crabs crowd at the water's edge seeking oxygen. Photo by Kevin Fleming
Upper Right: A waterman harvests crabs at dawn near the mouth of the Severn River. Photo by Tom Boddorff
Lower Left: An algal bloom fueled by nitrogen pollution clouds the water on Mattawomen Creek. Photo by John Surrick/CBF Staff
Lower Right: Participants in a National Geographic photo camp examine a juvenile blue crab. Photo by Ashley Lane

Bad Water and the Decline of Blue Crabs in the Chesapeake Bay

EXECUTIVE SUMMARY

Blue crabs are not only the most economically important fishery in the Chesapeake Bay. They are also a powerful icon of the whole mid-Atlantic region—a symbol of our cultural roots in the Chesapeake. And they are an essential strand in the web of life that forms the nation's largest estuary.

For all these reasons, it is a matter of grave concern that the blue crab population has fallen to near record lows. (FIGURE 1) Scientists say there are two causes of the problem: pollution and overfishing, especially of female blue crabs. (Overfishing means catching crabs faster than they can reproduce. See box on facing page.) Here are some key facts:

- **Less Crab Food** Low-oxygen "dead zones" on the bottom kill the food that crabs eat, wiping out or preventing the growth of 75,000 metric tons of clams and worms a year. That is enough food to support about half the commercial crab harvest, more than 60 million blue crabs annually.
- **Less Crab Habitat** Sediment from runoff and algal blooms caused by nitrogen and phosphorus pollution are darkening the Bay's waters, killing the underwater grasses that young crabs need as shelter from predators. More than half of the Bay's eelgrass has died since the early 1970s.
- **Overfishing** Because a diminished Bay can support fewer crabs, overfishing has become an even more urgent problem. Watermen have caught an average of 62 percent of the Bay's blue crabs each year over the last decade—well more than the 46 percent that scientists say is sustainable.
- **Regulation** If the Bay were cleaner and crabs more plentiful, watermen could continue to catch the same number of crabs they are harvesting today without exceeding the 46 percent threshold. Then, additional government regulation of watermen—and relief for them—might not be necessary.

In 2007, watermen suffered the worst crab harvest since Bay-wide record keeping began in 1945. 2008 was even worse in Virginia, and only slightly better in Maryland. Maryland and Virginia have endured more than $640 million in losses over the last decade because of the crab's decline. The states are taking immediate steps to prevent a potential collapse of the fishery. On October 23, 2008, Maryland banned the commercial harvest of female crabs until spring, and Virginia imposed the same prohibitions on October 27.

It does not have to be this way. If the federal government and the Bay states kept the promises they made to clean up the Bay by 2010, Maryland and Virginia might not have to impose as many restrictions on crabbing.

Historically, debates have raged worldwide as to whether environmental degradation or overharvesting is the primary cause for declines in various fish populations. This has been the case with respect to the blue crab. To formulate policy that will address the decline, it is important to first clearly determine the objective being pursued. If simply a greater abundance of crabs is the objective, taking fewer crabs will certainly accomplish that. The Chesapeake Bay Foundation, however, believes that the goal should be broader. The desired abundance of blue crabs in the Chesapeake can help support the local economy, as well as reflect environmental improvement. Although at least 4,486 crabbing related jobs have been lost over the last decade in Maryland and Virginia, 6,760 of these jobs remain. And CBF wants people who earn a living from the Bay to remain employed. The jobs dependent on crab populations include watermen who catch crabs, workers who process them, wholesalers and retailers, grocers, and restaurant employees. Our goal is better water quality not only for the blue crab and those who harvest them, but for all creatures, human and otherwise, who use and enjoy the Bay.

This report, compiled from interviews with 12 leading crab researchers and water quality experts as well as federal government data and scientific papers, describes the causes of the decline, and the actions needed to save the blue crab in the Chesapeake Bay. The U.S. Environmental Protection Agency (EPA) must impose a strong regulatory cap on pollution entering the Bay and assume a leadership role in enforcing the Federal Clean Water Act. And Maryland, Virginia, and Pennsylvania must do more to control agricultural runoff pollution.

The iconic Chesapeake blue crab and all of the region's 17 million residents deserve the clean water our governments have promised.

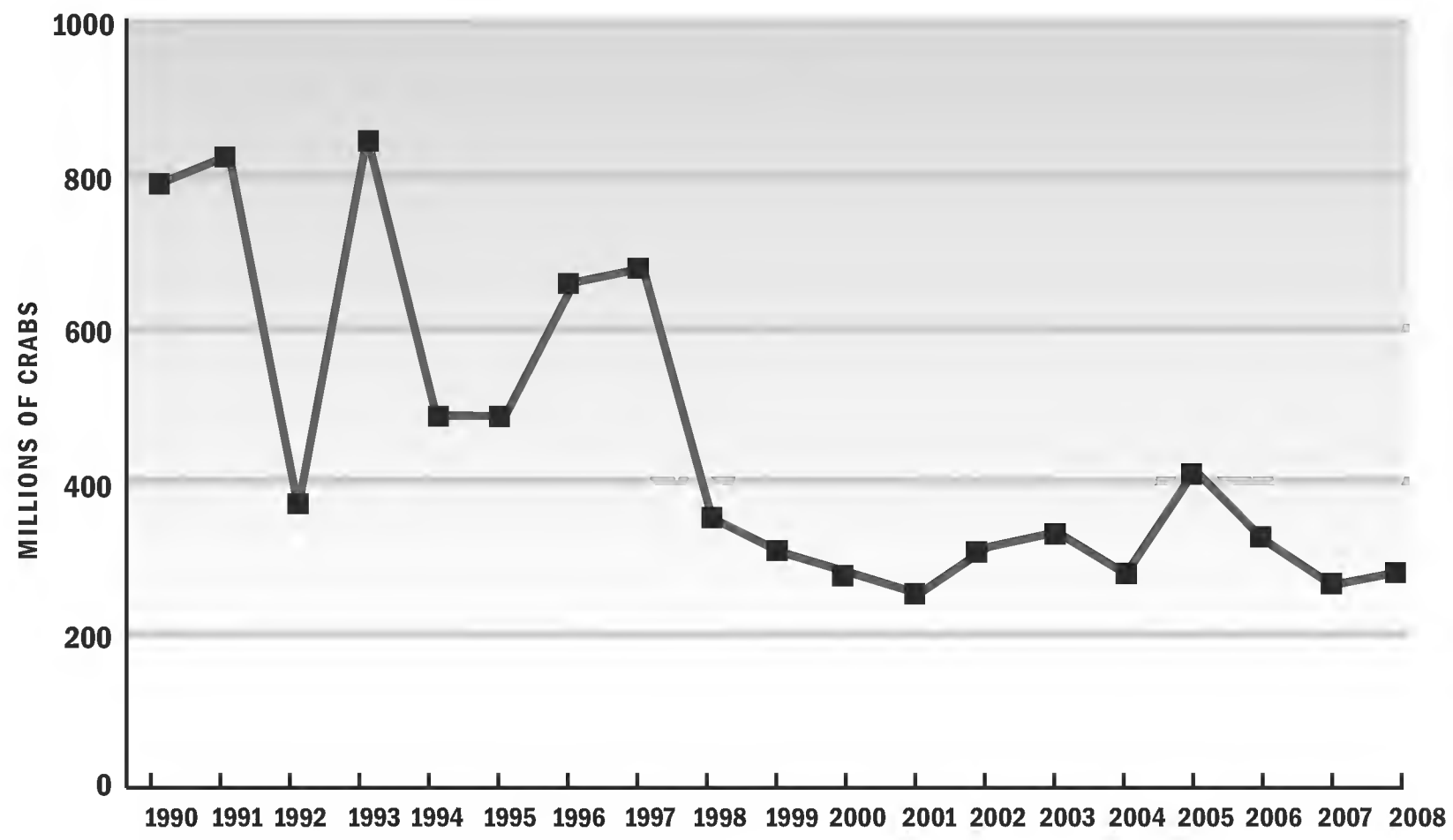
COMMERCIAL CRABBING AND THE CHESAPEAKE BAY

Historically, the Chesapeake Bay has been the most productive estuary in America. Author H. L. Mencken called it "an immense protein factory."[1] And as recently as the early 1990s, the Bay's crabbing industry seemed healthy. After the decimation of oysters, shad, and sturgeon, blue crabs are the Bay's last remaining major fishery, except for small schooling fish.[2] The variable but usually plentiful crab harvest from World War II through the 1980s masked a troubling fact—the effort used to catch the same number of crabs increased dramatically, with 60,000 crab pots in the Bay in 1948 and 665,000 pots four decades later.[3]

A record catch—347 million crabs worth about $107 million in today's dollars[4]—was hauled out of the Bay in 1993. That was about half of the nation's total blue crab catch.[5] But there has been a severe drop-off since then.

The harvest has plummeted by about two-thirds since the early 1990s, with 132 million crabs caught across the Bay last year worth about $52 million.[6]

FIGURE 1
TOTAL CRAB POPULATION

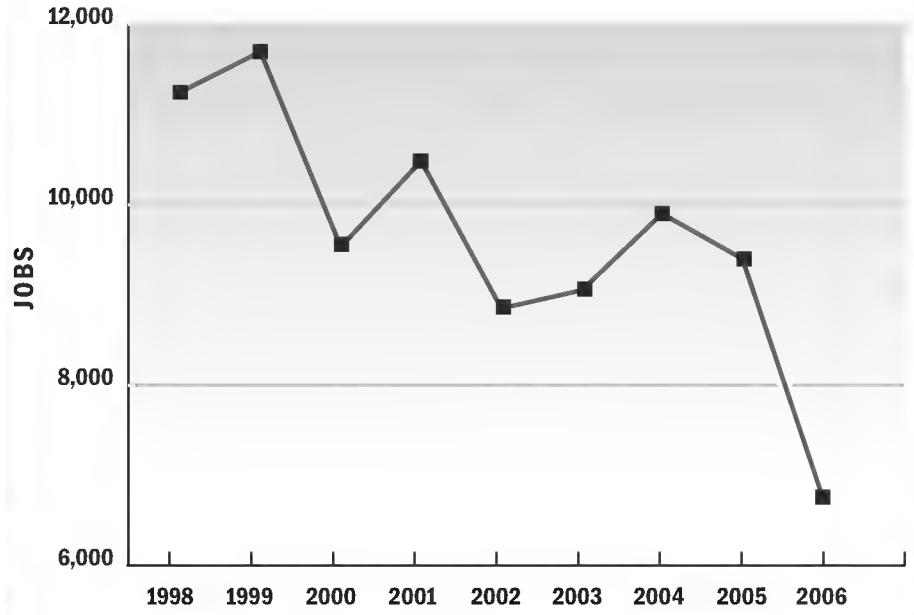


Source: National Oceanic and Atmospheric Administration

Jobs related to crabbing in Maryland and Virginia have fallen about 40 percent from 11,246 in 1998 to 6,760 in 2006, including roughly 3,100 remaining watermen doing the equivalent of 1,485 full-time jobs.[7] (FIGURE 2) (Many watermen have second jobs and crab only part of the year.) Recreational crabbing—an important part of local culture and the tourism industry—has also been hurt. When the broader impact on restaurants, crab processors,

wholesalers, grocers, and watermen is all added up, the decline of crabs in the Bay meant a cumulative loss to Maryland and Virginia of about $640 million between 1998 and 2006 (the most recent year for which this economic data is available).[8] (FIGURE 3) A federal declaration of economic disaster was approved by U.S. Secretary of Commerce Carlos Gutierrez on September 23, 2008, making watermen eligible for emergency relief.

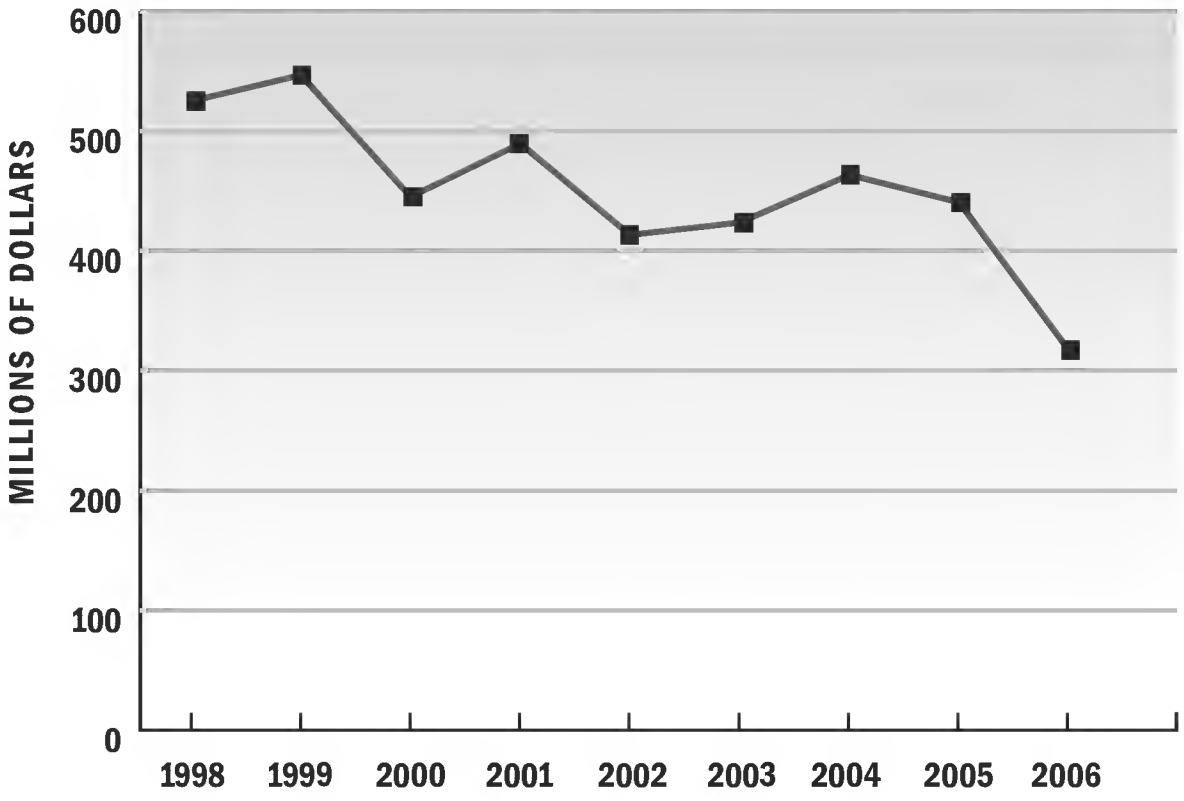
FIGURE 2



Data from Virginia Institute of Marine Science represents jobs in crab-related industries (watermen, crab dealers, processors, wholesalers, grocers, and restaurants) in Maryland and Virginia.

FIGURE 3

ECOMOMIC VALUE OF CRABBING IN MARYLAND AND VIRGINIA

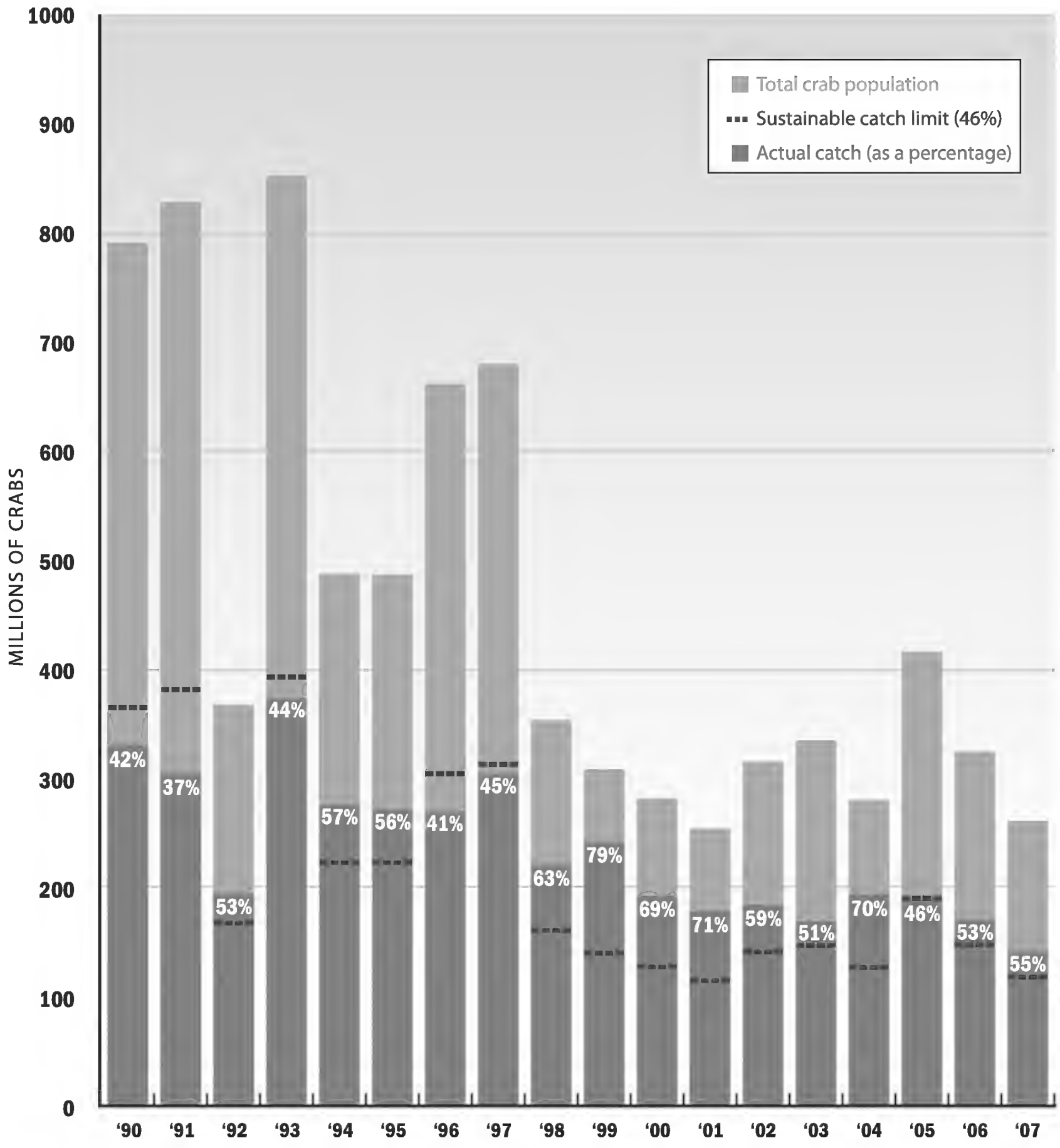


Revenue from watermen, dealers, processors, wholesalers, grocers, and restaurants.

Source: Virginia Institute of Marine Science

FIGURE 4

CHESAPEAKE REGION BLUE CRAB CATCH AS PERCENTAGE OF TOTAL POPULATION



Source: National Oceanic and Atmospheric Administration

CAUSES OF THE DECLINE: OVERHARVESTING AND POOR WATER QUALITY

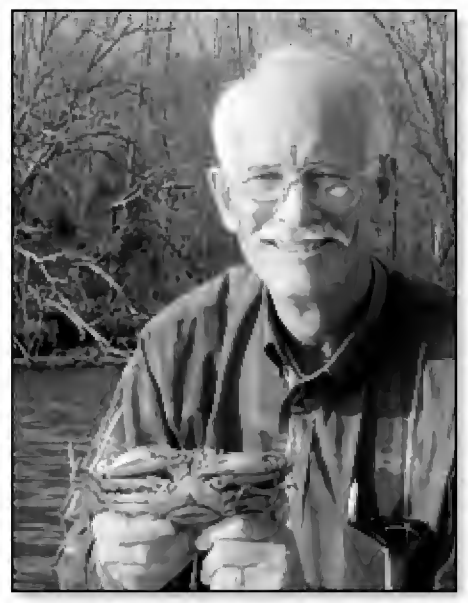
Leading biologists and the federal and state governments say the problem is two-fold: overfishing and pervasive poor water quality that causes a decline in habitat and food.

Overharvesting

In 2007—the last available data year—watermen caught 55 percent of the Chesapeake Bay's crabs. This so-called "exploitation fraction" was 70 percent in 2004, 71 percent in 2001, and it has averaged 62 percent over the last decade.[9] That is well over the 46 percent that scientists say is sustainable.[10] (FIGURE 4)

Reducing crab harvests in Maryland and Virginia was necessary in 2008 to prevent the potential collapse of the fishery. The rules prohibit the trapping or dredging of female crabs from October to April and limit the daily commercial catch of females in September and October. These restrictions are meant to reduce the annual catch to 46 percent of the total population and ensure there are enough breeding-age females. The generations-old tradition of dredging female crabs from the southern Bay over the winter has now been banned. Maryland also prohibited the recreational catching of female crabs beginning June 1, 2008, and Virginia did the same October 27.

But beyond these limits on harvesting, the states and the federal government are not doing enough to solve the more fundamental environmental problem—poor water quality—that is destroying the crab's habitat and food supply.



Dr. Anson "Tuck" Hines
Director
Smithsonian Environmental Research Center

"Are we going to change our ways? Are we going to continue to overharvest crabs? Are we going to continue to damage the environment and habitat?"

FIGURE 5

CHESAPEAKE BAY DEGRADATION CYCLE

Nitgrogen, phosphorus, and sediment pollution from farm runoff, sewage treatment plants, and other sources enter the Bay.

Nitgrogen and phosphorus pollution fuels excessive algae growth.

Algae and sediment cloud water and block sunlight.

Algae die and suck oxygen from the water.

Grasses die, leaving crabs without shelter.

Clams and worms die, leaving crabs without food.

Chesapeake Bay Blue Crab Population at Risk

Dr. Thomas J. Miller
Professor of Fisheries Science
University of Maryland
Chesapeake Biological Lab

"Clearly overharvesting is an important factor but not the sole factor contributing to the decline of the blue crabs."

Poor Water Quality

Nitrogen and phosphorus pollution stimulates excessive algae, which along with sediment pollution darken the water, blocking light needed by underwater grasses, killing them. (FIGURE 5) This leaves young crabs without places to hide from predators. When algal blooms die and rot, they create the low-oxygen zones that kill clams, worms, and other bottom-dwelling invertebrates, which are the main foods for crabs. Crabs also eat oysters, and studies have shown that low oxygen levels increase oysters' susceptibility to disease.[11] When oysters die, reefs get silted over and this important foraging ground is lost to crabs. An estimated 164,000 acres of oyster bar habitat have been lost in Maryland waters alone in the last twenty-five years.[12] Because of overharvesting, water pollution, sedimentation, and disease, vast swaths of the Bay's bottom have become muddy wastelands.[13]

A study published in the journal *Science* in August 2008 estimated the "dead zones" in the Chesapeake Bay kill or prevent the growth of about 75,000 metric tons of clams and worms every year. That's enough food to feed about half the commercial harvest[14]—or more than 60 million blue crabs a year.

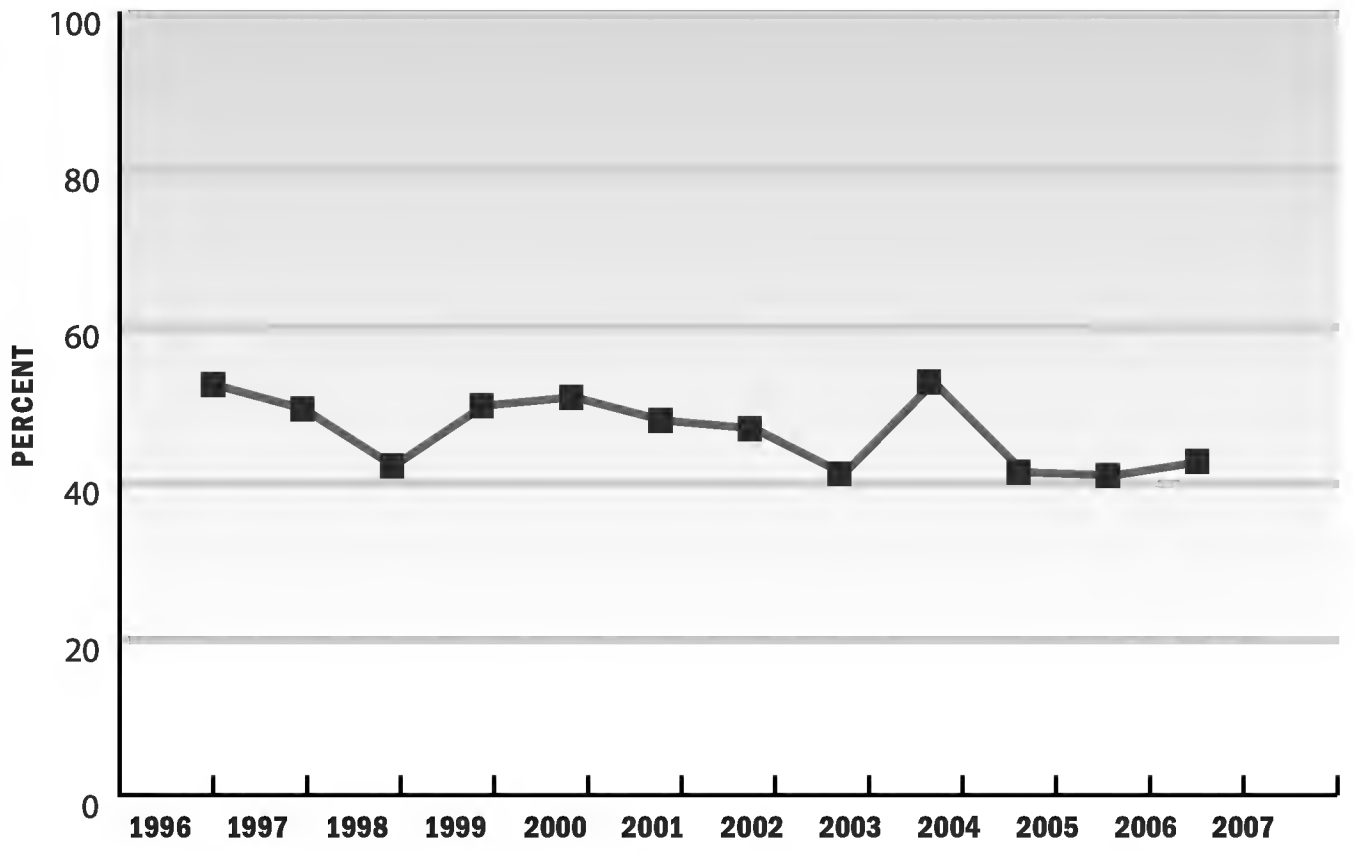
The percentage of the Bay's bottom with healthy amounts of crab food (clams, worms, and small crustaceans) has fallen over the last decade, from 52 percent in 1996 to 42 percent in 2007.[15] (FIGURE 6)

Dr. Robert J. Diaz
Professor of Marine Science
Virginia Institute of Marine Science
at the College of William
and Mary

"The dead zones mean the crabs don't have enough food... and crowded in shallow areas, they're more vulnerable to being fished."

FIGURE 6

PERCENTAGE OF THE BAY WITH HEALTHY AMOUNTS OF BENTHIC ORGANISMS (CRAB FOOD) ON THE BOTTOM



Source: U.S. EPA Chesapeake Bay Program

FIGURE 7

LOW-OXYGEN ZONES IN THE CHESAPEAKE BAY

Rank	Year	% Low Oxygen*
1	1989	48.45%
2	1986	47.41%
3	1995	43.25%
4	2008	40.17%
5	1993	38.80%
6	1987	38.64%
7	1992	37.24%
8	2004	37.08%
9	1998	36.15%
10	2005	35.39%
11	1999	34.88%
12	2006	34.29%
13	1991	33.85%
14	1985	31.80%
15	1988	31.17%
16	2002	31.06%
17	1994	30.86%
18	1996	30.09%
19	1990	28.91%
20	1997	28.24%
21	2000	27.72%
22	2003	26.76%
23	2007	21.59%
24	2001	16.46%

*percent of the Bay's main stem with less than 5 mg/liter dissolved oxygen in late July.

Source:
U.S. EPA Chesapeake Bay Program

Without food, crabs increasingly turn to cannibalism—further reducing their populations.[16] The spread of oxygen-deprived "dead zones" in the summer also forces crabs to flee into shallows, where they are more vulnerable to being fished. This crowding into narrow areas near shore is reflected in the clustering of commercial crab pots in the summer.[17] Buoys marking crab pots are routinely packed into waters ten feet deep or less.

Monitoring of the Chesapeake in late July found that 40 percent of the Bay was so starved of oxygen that the waters would stress or kill aquatic life (less than 5 mg per liter of dissolved oxygen or hypoxic conditions).[18] The July reading was the fourth worst for a similar period since monitoring began in 1985. (FIGURE 7) Testing in early August showed the sixth worst low-oxygen zones on record for that period.

Blue crabs will likely persist in the Bay—but there could be a lot fewer of them in the future. A dredge survey last winter found the crab population had fallen 16 percent since the previous year and 70 percent since 1990.[19] (See "Blue Crab Fishery Management" on page 15.) When all crabs—young and old—are taken into account, the total blue crab population in the Bay has plummeted from 791 million in 1990 to 260 million in 2007.[20]

That steep decline has been caused in part by water pollution, which has eroded the Bay's carrying capacity—the ability of an ecosystem to support a population such as blue crabs.[21]

For the crab, underwater grass beds, oyster reefs, and dissolved oxygen levels are key elements of the Bay's carrying capacity. They determine the crab's ability to hide from predators, find food, grow, and reproduce. As these factors are diminished, the Bay's carrying capacity shrinks, meaning fewer crabs can be produced and maintained in the estuary.

Some experts have compared the Bay's declining carrying capacity to that of an evaporating lake or a shrinking pond.[22] Fish and crabs are being packed into smaller and smaller areas, and the whole system is more fragile and vulnerable—and therefore fishing must be managed more carefully.

Dr. Donald Boesch
President
University of Maryland Center for Environmental Science

"Because of deteriorating environmental problems, the carrying capacity of the Bay is reduced. Low oxygen zones and the loss of submerged vegetation are high on the list of things we're concerned about."

Lynn Fegley
Assistant Director
Fisheries Service
Maryland Department of Natural Resources

"The pond is shrinking, and it is critical that we keep the fisheries in balance with a more limited ecosystem."

LOW OXYGEN LEVELS AND BLUE CRABS

On the clear blue morning of August 19, George Abbe steered a 20-foot-long Seahawk fishing boat out of Flag Harbor in Southern Maryland and onto a calm Chesapeake Bay.

In many ways, it was a routine day for Abbe, an assistant professor at Morgan State University's Estuarine Research Center. He had been baiting and checking crab pots in this area for four decades as a way of monitoring the Bay's crab populations.

But when Abbe pulled up five of his traps from 16 feet of water off Kenwood Beach, he saw something worrisome—the equivalent of canaries in a coal mine. Twenty-five of the 32 crabs in the pots were dead. The other seven were sluggish, dying from asphyxiation.

Abbe dropped an electronic probe into the water. He found that dissolved oxygen levels had plummeted to almost zero overnight—falling from 4.3 mg per liter the day before to 0.4 mg per liter, low enough to kill crabs or almost anything else. He concluded that persistent southwest winds had pushed the Bay's healthier surface waters to the east during the night, bringing up a low-oxygen "dead zone" from the bottom.

George R. Abbe
Assistant Professor
Morgan State University's
Estuarine Research Center

"A true dead zone will kill a crab relatively easily," Abbe said. "Had these crabs not been trapped, they would have simply moved into shallower water, with higher oxygen levels, and survived. But because they're trapped in pots, if the oxygen level drops too low, it'll kill them."

It was a phenomenon Abbe had seen many times before—usually in the hottest months of summer. "Dead zones" are created when rain washes nitrogen and phosphorus off farm fields, suburban lawns, and other places, spurring the excessive growth of algae. The algae die and decompose—sucking the oxygen out of the water.

The day after he found the dead crabs, Abbe headed back out to the site to check his pots again. The wind had since changed direction, the dead zone had retreated to deeper water—and so now the crabs in his traps were alive. His research assistant, Hank Curtis, hauled a pot onto the boat, then dumped six blue crabs onto a table. They scrambled and raised their claws for combat.

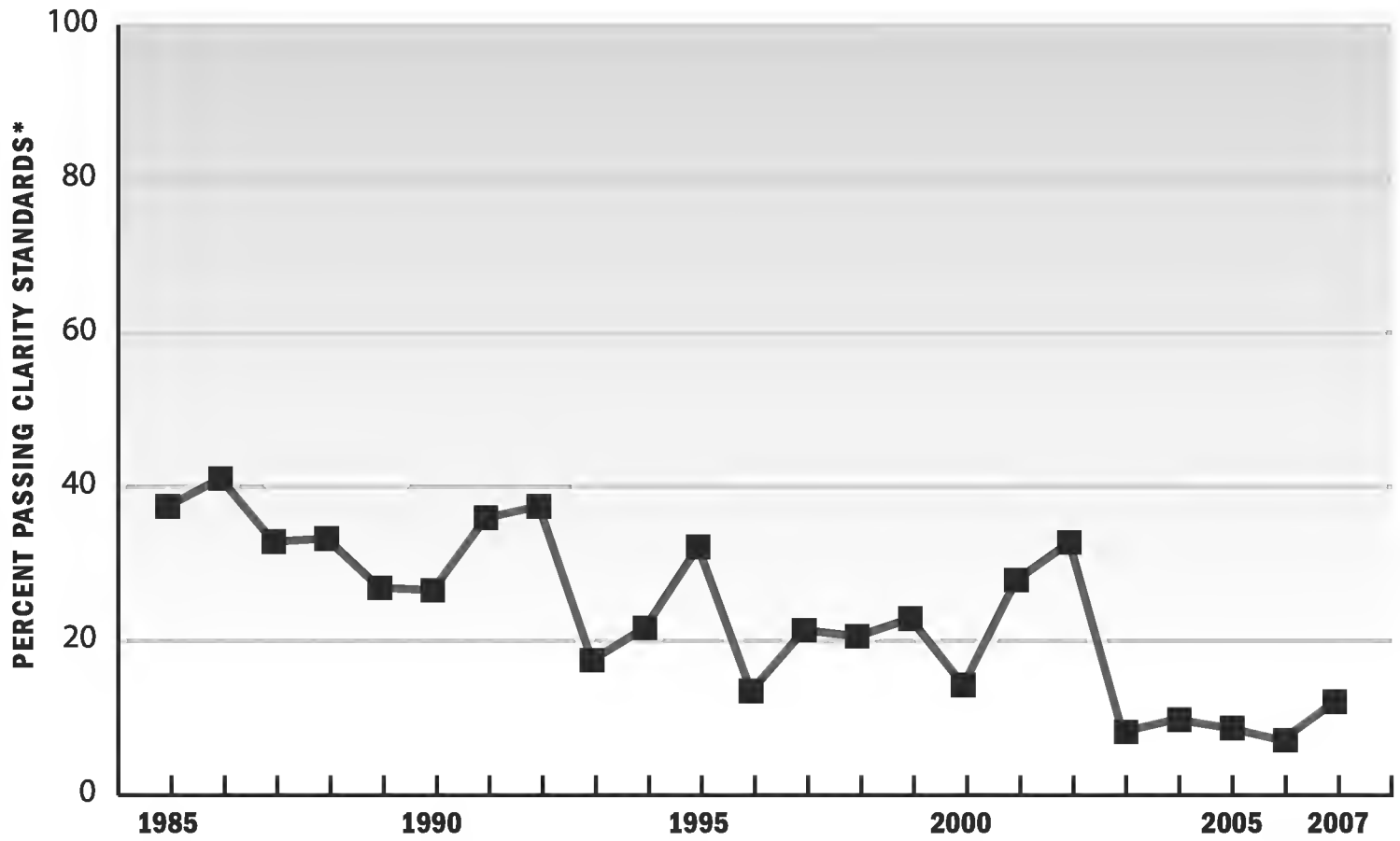
Protected by thick orange rubber gloves, Abbe measured the crabs with a ruler, sorted them by sex into red buckets, and weighed them. It is a process the scientist has repeated every summer since 1968. His research found a trend, which he reported in the journal *Estuaries* in 2002. His data shows a 65 percent decline in the number of legal-sized (measuring five inches or more) male blue crabs he caught over three decades. From 1968 to 1972, he caught 1,033 annually off Calvert Cliffs. From 1996 to 2000, he caught 364 per year on average using the same amount of effort.

"Crab populations bounce all over the place," reflected Abbe. "But over the long term we're seeing fewer commercial-size crabs."

Nitrogen and phosphorus are at the center of the Bay's failing health. These pollutants bring darkness to the estuary. Nitrogen and phosphorus stimulate the excessive growth of algae, which absorb and scatter light. With more cells, sunlight is blocked from penetrating the water. In the upper Bay, nitrogen and phosphorus pollution caused a 250-fold increase in the density of algae cells from the 1950s to the 1980s.[23] In part because of all the algae, the percentage of the Bay meeting water clarity standards has fallen from 38 percent in 1985 to 12 percent in 2007.[24] (FIGURE 8)

FIGURE 8

DECLINING WATER CLARITY IN THE CHESAPEAKE BAY



Source: U.S. EPA Chesapeake Bay Program

* Clarity standards are set by U.S. EPA Chesapeake Bay Program based on the darkness of water, which reflects algae content and suspended solids.

The effect is clear: Light needed by plants is not reaching the bottom. And the resulting darkness is killing aquatic grasses, especially eelgrass, the dominant species in the saltier southern Bay.

Eelgrass beds in the lower Bay have shrunk by more than half since the early 1970s. One factor in the decline of eelgrass is climate change, with hotter Bay water temperatures—especially in the record-breaking summer of 2005—cooking this heat-sensitive plant.[25] Bay-wide, hundreds of thousands of acres of underwater grasses of all varieties have disappeared over the last century because of water pollution and other factors.[26]

EELGRASS AND THE BLUE CRAB LIFECYCLE

Dr. Robert J. Orth
Professor of Marine Science
Virginia Institute of
Marine Science

"The eelgrass beds provide lots of cover. They are a key ingredient in the crab's life history."

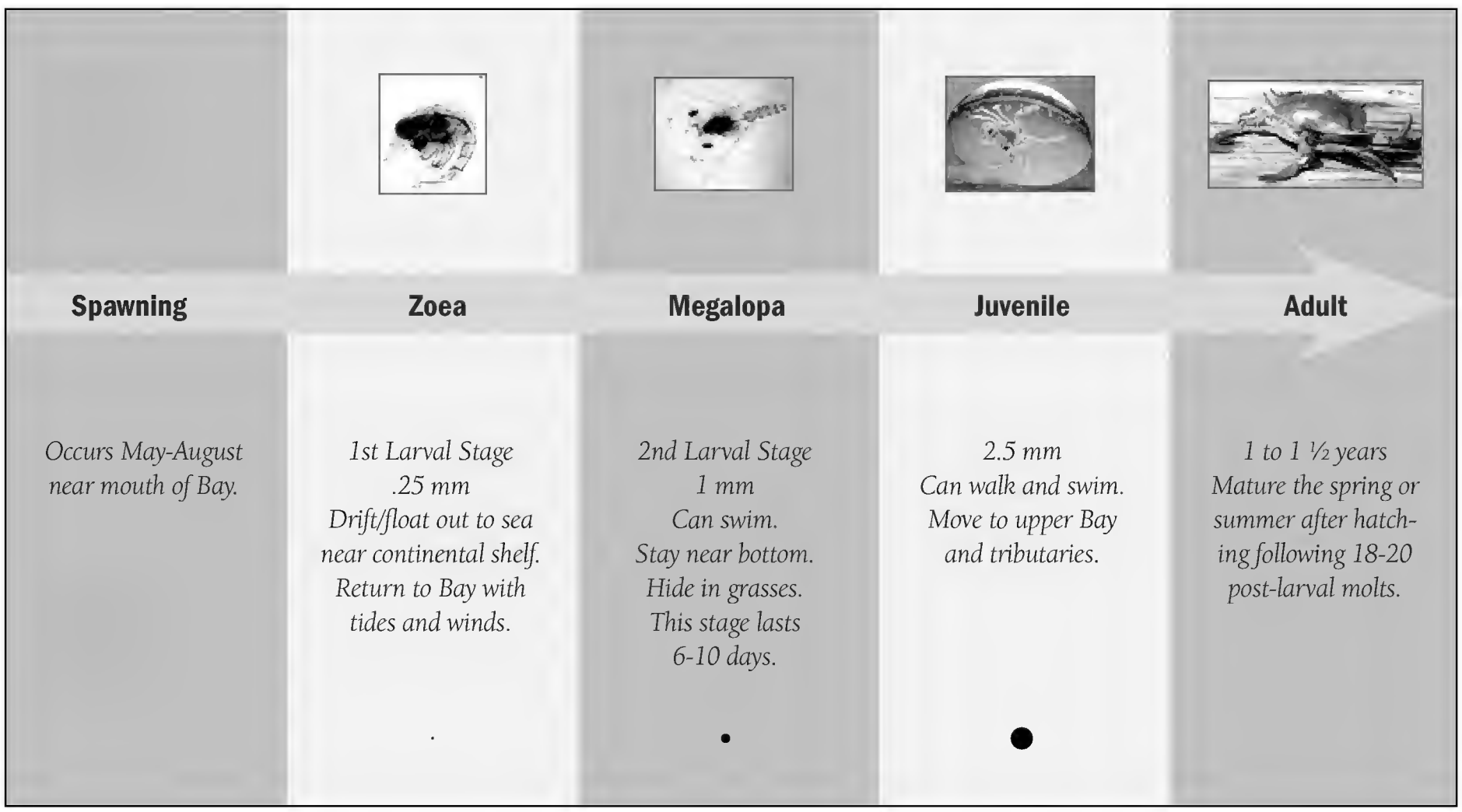
The disappearance of eelgrass is especially harmful to crabs because a crucial part of their lifecycle unfolds in the southern Bay, among these underwater plants with long, slender leaves.

Blue crabs spend the first months of their life as larvae, floating free in the Atlantic Ocean. (FIGURE 9) Then they are swept by currents into the southern Bay. At this point, they look like tiny lobsters and they are called megalopae. But essentially they are a form of plankton.

The megalopae settle out of the water column in the southern Bay into the eelgrass where they find shelter from predators like red drum and croakers. Without the hiding places, the megalopae would be gobbled up. Scientists have counted 30 times more young crabs in grass beds than on the barren bottom.[27]

Eating smaller crustaceans that thrive in the grass, the megalopae molt and grow into juvenile crabs. Over a period of two or three weeks, the crabs molt about a half dozen times in the protective jungle of underwater plants. When they are big enough to move out—about a half inch—the crabs start migrating northward up the Bay, where many spend much of their lives.

FIGURE 9
CRAB LIFECYCLE



The retreat of eelgrass may hold an answer to the crucial question of why blue crab populations fell off after 1990 after being robust the previous half century.[28]

While different varieties of grass in the northern Bay (some of them exotic species) have done well in recent years, they are not vital to the crab's survival. It is the eelgrass in the southern Bay that has significantly withered or died off since about 1990. (FIGURE 10)

However, the fact that crabs have been hurt by the disappearance of eelgrass—as well as nitrogen and phosphorus pollution and low-oxygen "dead zones"—does not mean that harvest pressure is not also an important issue.

If the Bay were healthier, it would support a larger total number of crabs. So if the watermen caught the same number they are taking out today, the percentage they would be landing would be lower—and it might not exceed the 46 percent level that scientists have identified as key for sustaining the species.[29]

With a clean Bay, Maryland and Virginia might not be forced to impose as many new restrictions on crabbing. But when the crab population declines so steeply, the states have no choice but to step in and impose more limits. Because a polluted Bay holds fewer crabs, harvests must be reduced for this vital part of Chesapeake life to be sustainable.

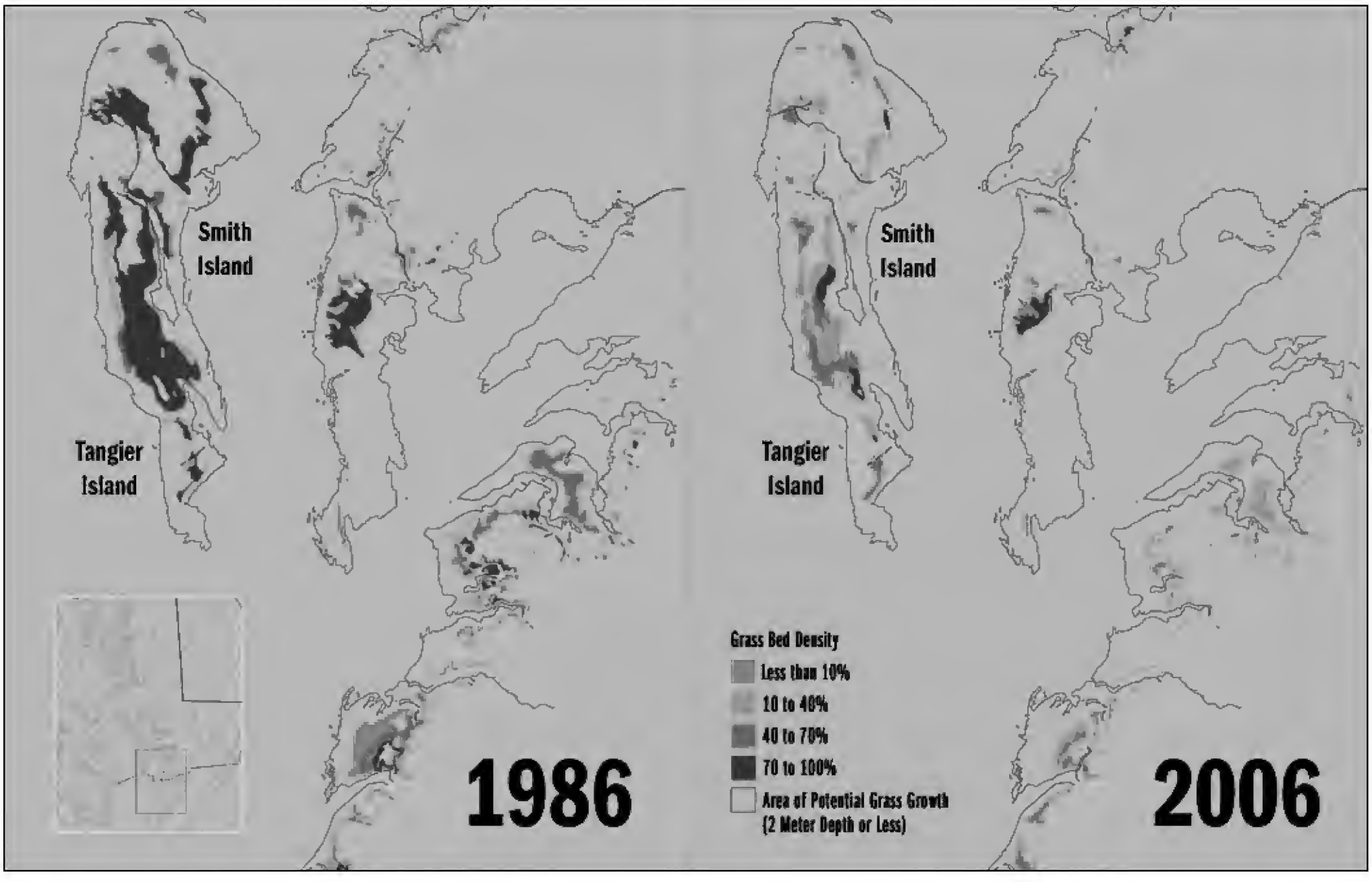
For this reason, watermen are becoming among the loudest advocates for a cleaner Bay.

Dr. Romuald N. Lipcius
Professor of Marine Science
Virginia Institute of
Marine Science

"Watermen are definitely victims of the degradation of the Chesapeake Bay...It's a vicious circle they're caught in.... And that is an unfortunate consequence of a damaged environment."

FIGURE 10

TWO DECADES OF AERIAL MAPPING REVEAL SHRINKING GRASS BEDS IN THE SOUTHERN BAY



Source: Virginia Institute of Marine Science SAV Monitoring Survey

BLUE CRAB FISHERY MANAGEMENT

Over the last two decades, scientists have learned a lot about the Chesapeake Bay blue crab and have developed scientific guidelines for managing the crab fishery.

For many years scientists assumed that blue crabs in the Bay could not be overfished. Mature female crabs spawn in the lower Bay during summer, and their larvae are swept out into the ocean. After developing for a few weeks they rely on fall easterly winds to be pushed back into the Bay. When the Bay's crab population was relatively healthy, these fickle fall winds determined the success of annual crab reproduction.

But analyses have now shown that reducing the number of spawning female crabs below a certain level will diminish reproductive success by reducing the production of larvae. These analyses have allowed scientists to set a target minimum number of adult crabs (200 million) necessary to maintain a healthy population.

Similarly, scientists have set a target rate of crabbing that will not diminish the population over time. That sustainable rate is 46 percent of the crab population harvested in a given year. This means that the population can reproduce fast enough and individual crabs can grow fast enough to replace the 46 percent that are caught by crabbers, and the population can maintain itself.

When in early 2008 crab numbers were found to be down to about 120 million adults, a near-record low, it became apparent that severe cutbacks in the fishery were going to be needed. Scientists determined that the best strategy to keep the harvest from exceeding the target rate (46 percent) and to rebuild the population to the target number (200 million adults) was to cut the harvest of mature female crabs by about a third. (When both adult and young crabs are included, there are about 260 million blue crabs in the Bay. But fisheries managers set their target based on adult crabs, because they reproduce and their numbers fluctuate less widely than young crabs). The new restrictions on harvesting—although necessary—hit some crabbers particularly hard, and government aid has been made available to help them through this period.

Some crabbers believe that degraded water quality is the primary cause of the crab population decline. Nitrogen and phosphorus pollution destroys underwater grass beds that provide crabs protection from predators like striped bass, and it leads to dead zones that crowd crabs from key habitat. But too much harvesting is also a big part of the picture as scientific analyses have shown.

The hard reality is, it does not matter what caused the decline in crabs. In the short term, managers have no alternative but to cut back on the rate of removal of crabs. However, the need for these severe restrictions on the fishery and their impacts on crabbing communities should further underscore the urgency of dealing with problems like nitrogen and phosphorus pollution and loss of underwater grasses in the longer term.

And crab management has to get beyond year-to-year restrictions and deal with the fundamental problem of too much overall crabbing "effort" (amount of crabbing gear and amount of time it is deployed). In other words, there is currently much more capability to catch crabs than is necessary to sustainably utilize this resource. The result is much lower "catch-per-unit effort." Crabbers work harder for fewer crabs, and the crab population is held at a low and unstable level.

One solution is to cut back on the total effort in the fishery using a system that allows crabbers to buy and sell their allowable effort ("transferability"). As total effort is reduced, some crabbers buy effort allocations to stay crabbing, and others sell and leave the fishery, but they make the decision. An essential element of this approach is a system called "pot tagging," in which crab pots are required to bear a state-supplied tag so that limits on the numbers of pots can be enforced. The end result will be better catch-per-unit effort and a more stable crab population.

Of similar merit is a system employing transferable quotas in which crabbers would have individual seasonal catch limits that could be traded. Such a system could be based on annual surveys that project how many crabs can be removed from the population each year. In the event that transferability proves too difficult to implement, simple daily catch limits could be a viable alternative for the short term.

Maintaining a restored crab population will be just as important as rebuilding it. CBF supports the use of a sanctuary corridor to provide protection for mature female crabs as they migrate down the Bay in fall and spring. The objective is to ensure that enough of them complete the migration and spawn.

In summary, the crab restrictions imposed in 2008 are only a stopgap measure. Long-term management will be most successful with a transferable effort or quota program, a pot-tagging program, and a migratory corridor sanctuary. Only by restructuring the fishery, along with improving water quality, will we save the blue crab.

CRAB JUBILEES

Kevin Fleming

Crabs crawl out of the water to get oxygen when dead zones force them ashore.

"Crab jubilees" are probably the most dramatic demonstrations of the effect of bad water quality on Bay life. The term sounds cheerful, but it is an ugly problem. Blue crabs and other organisms literally crawl out of the water seeking oxygen when wind and tide combine to force dead zones all the way to the shoreline. These "jubilees" probably occur a few times a year, but documentation is very poor.

At least two such events were documented in 2008. A July jubilee near Calvert Cliffs, in southern Maryland, was reported by ecologist Kent Mountford in the *Bay Journal*. And in late August, ferry riders in Portsmouth, Virginia, saw scores of blue crabs out of the water, clinging to pilings and docks, as dead fish floated in the water beneath them, according to the (Norfolk) *Virginian Pilot*.

The dead zone's massive volume of water nearly devoid of oxygen fills the deeper sections of the Bay for about four months during the hottest time of the year. During this time the Bay is stratified into two distinct layers, a surface, oxygenated layer, and the deeper dead zone. Circulation between the two is limited due to temperature and salinity differences.

But the two water layers can move around, especially if the surface layer is driven by the wind. When the wind blows across the Bay it pushes surface waters away and draws deeper waters up onto the shoulders of the channel and into shallow water. Crabbers working pots along the flanks of the main Bay sometimes have huge catches of crabs followed a day later by empty pots. This is when the timing is just right and they fish their pots as a mass of crabs and other organisms are moving toward shore ahead of advancing dead zone waters. If the timing is not ideal, those crabs can be trapped and overtaken by the suffocating water, and the crabber pulls up pots full of dead crabs.

Strong and protracted cross-Bay winds cause pronounced upwelling of the deeper, low-oxygen water that can draw dead zones all the way to the shoreline. Anything that needs oxygen (all fish and any mobile invertebrates like blue crabs) will move toward shore, eventually crowding at the water's edge seeking oxygen. A host of sedentary or slow animals—including clams, oysters, mussels, mud crabs, and a variety of small bottom-oriented fish—are overtaken by the dead zone and either die or endure a period of stress until the waters recede.

Crabs are the lucky ones, because they can crawl out of the water and breathe air for a brief period. But when an otherwise hardy animal like a crab must leave the Bay because it can not survive, it should be obvious there is a serious problem. They call it a jubilee because people on the shore can easily collect a crab dinner. But it is anything but a joyous occasion for the crabs.

STEPS NEEDED TO IMPROVE WATER QUALITY

Key to achieving cleaner water for crabs is aggressive leadership on Bay restoration from the federal and state governments. A return to a healthy crab population will not happen with the status quo.

Create an Enforceable, Accountable Pollution Cap

Currently, as required by the Clean Water Act, EPA and the states of the Bay region are working on a pollution budget, or a "cap," for the Bay that will set the maximum amount of nitrogen, phosphorus, and sediment pollution that a healthy Bay can tolerate. This regulatory cap, called a Total Maximum Daily Load (TMDL), will only be effective if it does two things. First, it must address pollution from all potential sources—streets and highways, parking lots, farms, septic fields, construction sites, etc. Second, it must be aggressive and provide for accountability. It is critical that the EPA, which holds the ultimate responsibility for the scope and effectiveness of the TMDL, along with the states adopt a TMDL that includes clear, measurable, pollution-reduction goals with consequences for failure to achieve those goals.

Enforce and Toughen Regulations

The TMDL is not, however, the only tool EPA should and must use to improve water quality in the Bay and its rivers. There are a great many clean water laws on the books. EPA and its partner state governments need to enforce these laws, whether they be sewage treatment plants seeking to discharge more pollution than currently permitted or "bad actor" provisions for farmers unwilling to control runoff. There is also a need for new laws and regulations: Currently, projected improvements to air quality are at risk because a court threw out recent federal clean air rules. Air pollution affects the Bay when rain washes nitrogen and other contaminants into our waterways. EPA must drive the federal government effort in fixing this problem by passing new laws or new regulations. Pennsylvania, Maryland, and Virginia are all in the midst of updating stormwater regulations and permits. These must be stringent with clearly defined pollution-reduction criteria and standards.

Reprioritize Investments

With the current financial crisis facing the nation, it is even more important that dollars spent on clean water be done in a manner that yields the greatest pollution reductions. Whether it be existing dollars available through current programs or new dollars proposed through the economic stimulus package, government needs to get the best "bang for the buck." For example, an allocation of only one percent of the billions of dollars that the federal government provides to the states to help with highway construction through the Surface Transportation Bill could provide about $200 million for highway pollution reduction in the Bay watershed and achieve significant pollution cuts over the next five years. Another opportunity lies with the economic stimulus package. The stimulus package can bring new life to the economy as well as the Bay and its rivers by providing money for sewage treatment plant upgrades through the federal Clean Water State Revolving Fund, and by making sure all highway projects include runoff pollution control systems. Smart

targeting of federal investments such as these—as well as funds designed to reduce agricultural pollution—is good government and good resource protection.

Virginia, which has established a "top-five" list of best agricultural conservation practices, provides an example of good targeting of government dollars. Still, Virginia's current investments must be maintained and increased in future years. Ongoing targeting of Maryland's Chesapeake Bay 2010 Trust Fund dollars (halved last year from its authorized amount) toward the most effective runoff control practices in targeted watersheds is similarly critical.

Provide Incentives and Foster Innovation

Pennsylvania has led the way with incentives for pollution reduction with the adoption of REAP (Resource Enhancement and Protection Act). It is a transferable tax credit program available to farmers and businesses committed to reducing pollution from farm fields and barnyards. With 100 percent of the available credit allocation snapped up by farmers within one day of issuance, it is clear that authorization of REAP is just the tip of the incentive iceberg. Pennsylvania should increase the allocation. Innovation is an equally fertile field for engaging businesses and industry in clean water efforts. Whether it be precision feeding for dairy herds or waste-to-energy initiatives using poultry litter, there is a need for governments and the private sector to increase the opportunity and funding necessary to drive innovation. They must also play a role in helping to encourage market-oriented solutions, such as green labeling or funds that leverage private pollution-reduction investments.

Through tough regulation, efficient use of money, incentives to reduce pollution, and enforcement of environmental laws, the federal and state governments can save the blue crab and save the Bay. It is time for action, before a key part of the Chesapeake becomes just another part of its history.

END NOTES

[1] Henry Lewis Mencken, *Happy Days, volume 1*. Alfred A. Knopf Inc., New York, NY, 1940.

[2] Menhaden remain a major fishery in the Chesapeake Bay, with these small oily fish harvested and sold for not only bait, but also for farm animal feed and fish-oil supplements for humans.

[3] Tom Horton, *Turning the Tide: Saving the Chesapeake Bay.* Second Edition. Island Press, Washington, D.C., 2003.

[4] Data provided by Dr. James Kirkley, Professor of Marine Science at the Virginia Institute of Marine Science.

[5] Data provided by Derek Orner, Fisheries Biologist at the National Oceanic and Atmospheric Administration.

[6] Data provided by Lynn Fegley, Assistant Director of the Fisheries Service at the Maryland Department of Natural Resources.

[7] Estimates of numbers of total watermen today provided by the Maryland Watermen's Association and the Virginia Marine Resources Commission. Number of total full-time equivalent crabbing jobs from Dr. James Kirkley, Professor of Marine Science at the Virginia Institute of Marine Science.

[8] Data provide by Dr. James Kirkley, Professor of Marine Science at the Virginia Institute of Marine Science.

[9] Exploitation fraction data provided by Derek Orner, Fisheries Biologist at the National Oceanic and Atmospheric Administration.

[10] Chesapeake Bay Stock Assessment Committee, *Chesapeake Bay Blue Crab Advisory Report*, July 2008.

[11] Anderson, R.S., et al., *Journal of Fish Disease*, volume 21, 1998.

[12] Maryland Oyster Advisory Commission, *2007 Interim Report*.

[13] Disappearance of oyster beds is due to historical overharvest, sedimentation, and disease, according to written comments by Dr. Donald Boesch, President of the University of Maryland Center for Environmental Science on September 30, 2008. The lack of oyster beds hurts crabs, according to interview on August 21, 2008, with Dr. Romuald Lipcius of the Virginia Institute of Marine Science.

[14] Dr. Robert J. Diaz and Rutger Rosenberg, "Spreading Dead Zones and Consequences for Marine Ecosystems," August 15, 2008, *Science*. Data on number of crabs caught from U.S. Environmental Protection Agency's Chesapeake Bay Program. 175 million blue crabs a year have been caught in the Bay on average over the last 10 years, with 2007 lower, at 132 million crabs.

[15] Data from the U.S. Environmental Protection Agency's Chesapeake Bay Program.

[16] August 19, 2008, interview with Dr. Robert J. Diaz, Professor of Marine Science at the Virginia Institute of Marine Science at the College of William and Mary.

[17] Chesapeake Bay Foundation field staff observations.

[18] U.S. Environmental Protection Agency's Chesapeake Bay Program data provided by Jacob Goodwin, monitoring staff member at the Chesapeake Research Consortium, and Jeni Keisman, Water Quality Analyst with the University of Maryland Center for Environmental Science.

[19] Chesapeake Bay Stock Assessment Committee, *Chesapeake Bay Blue Crab Advisory Report*, July 2008.

[20] Data provided by Derek Orner, Fisheries Biologist at the National Oceanic and Atmospheric Administration. Interview on August 14, 2008, with Dr. Donald Boesch, President of the University of Maryland Center for Environmental Science.

[21] Eugene Odum, *Fundamentals of Ecology*. Brooks Cole, 1971.

[22] Interview on August 13, 2008, with Lynn Fegley, Assistant Director of the Fisheries Service at the Maryland Department of Natural Resources.

[23] U.S. Environmental Protection Agency, *Chesapeake Bay: A Profile of Environmental Change*, 1983.

[24] Data from the U.S. Environmental Protection Agency's Chesapeake Bay Program.

[25] Interview on August 19, 2008, with Dr. Robert J. Orth, Professor of Marine Science at the Virginia Institute of Marine Science.

[26] Tom Horton, *Turning the Tide: Saving the Chesapeake Bay.* Second Edition. Island Press, Washington, D.C., 2003.

[27] Chesapeake Bay Foundation, *Climate Change and the Chesapeake Bay*, July 2007.

[28] Interview on August 15, 2008, with Dr. Thomas J. Miller, Professor of Fisheries Science at the University of Maryland's Chesapeake Biological Lab.

[29] Interview on August 21, 2008 with Dr. Romuald N. Lipcius, Professor of Marine Science at the Virginia Institute of Marine Science.

HOW THIS REPORT WAS COMPILED

Chesapeake Bay Foundation Senior Writer Tom Pelton and CBF Fisheries Director Bill Goldsborough were the primary authors of this report. They interviewed 12 leading crab researchers and water-quality experts, reviewed data from the U.S. EPA Chesapeake Bay Program and other sources, read scientific papers, and spent time on the water with a veteran crab researcher.

CBF thanks the 12 scientists and experts who were interviewed: George R. Abbe, Assistant Professor at Morgan State University's Estuarine Research Center; Dr. Richard Batiuk, Associate Director for Science at the EPA Chesapeake Bay Program; Dr. Donald Boesch, President of the University of Maryland Center for Environmental Science; Dr. Robert J. Diaz, Professor of Marine Science at the Virginia Institute of Marine Science (VIMS); Lynn Fegley, Assistant Director of the Fisheries Service at the Maryland Department of Natural Resources; Dr. Anson "Tuck" Hines, Director of the Smithsonian Environmental Research Center; Jeni Keisman, Water Quality Analyst with the University of Maryland Center for Environmental Science; Dr. James Kirkley, Professor of Marine Science at VIMS; Dr. Romuald N. Lipcius, Professor of Marine Science at VIMS; Dr. Thomas J. Miller, Professor of Fisheries Science at the University of Maryland's Chesapeake Biological Lab; Derek Orner, Fisheries Biologist at the National Oceanic and Atmospheric Administration; Dr. Robert J. Orth, Professor of Marine Science at VIMS at the College of William and Mary.

Four outside scientists also reviewed the whole report for accuracy: Dr. Donald Boesch, President of the University of Maryland Center for Environmental Science; Dr. Thomas J. Miller, Professor of Fisheries Science at the University of Maryland's Chesapeake Biological Lab; Dr. Robert J. Diaz, Professor of Marine Science at Virginia Institute of Marine Science; and Dr. Anson "Tuck" Hines, Director of the Smithsonian Environmental Research Center. Many thanks to them for their help.

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Chesapeake Bay Watershed

The Chesapeake Bay's 64,000-square-mile watershed covers parts of six states and is home to more than 17 million people.

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